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ABSTRACT

A set of studies investigated the relative importance of operative schemes and figurative (rote) memory. In Study I, 60 concrete operational children from grades 1-4 were asked to reconstruct two types of stimuli from memory. In order to separate the effects of operative and figurative skill use, learning disabled children with poor figurative memories were compared to children with normal memory skills. In one type of stimulus condition (an arbitrary color sequence) the elements of the display were presented in an unorganized manner so that operative schemes would be of relatively little use for memory. In a second type of stimulus condition, (a seriated array) elements were organized so that operative schemes would be highly relevant. As predicted, a significant Group X Stimulus interaction was found, with the learning disabled children performing comparably well to normal children on the seriated stimulus, but worse than the normal children on the arbitrary stimulus due to their deficient figurative memory skills. In Study II, 20 preschool children (mean age, 4 years, 6 months) classified as nonseriaters were given the same memory tasks to determine whether the tasks were equivalent figuratively for children lacking the relavent operative schemes. As predicted, there was no significant difference between performance in the two types of stimulus conditions. To determine whether preschoolers could understand the organized stimulus, 14 preschool children classified as seriaters were tested on the same tasks in a third study. Performance in the organized stimulus condition was significantly better than performance in the unorganized stimulus condition. These results lend support to Piagetian theory. (Author/SS)

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FIGURATIVE AND OPERATIVE BASES OF MEMORY: EVIDENCE FROM NORMAL AND LEARNING DISABLED CHILD

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Abstract

Figurative and Operative Bases of Memory:

Evidence from Normal and Learning Disabled Children

Piagetian memory research shows that older children remember operatively-derived stimuli better than younger children. Here, the relative importance of operative schemes and figurative (rote) memory was investigated. In Study 1, 60 concrete operational children--half with deficits in visual memory (learning disabled, LD) and half without--were asked to reconstruct two stimuli from memory, one in which operative schemes were relevant (a seriated array), the other in which they were not (an arbitrary color sequence). Consistent with the hypothesized importance of operativity, a significant Group X Stimulus interaction was found, with LD children performing comparably to normal children on the seriated stimulus, but worse on the arbitrary stimulus. In Study 2, 20 seriating preschoolers were given the same memory tasks to determine if the observed interaction could be attributed to the seriated array being figuratively easier. No stimulus effect was found. To ascertain that preschoolers could understand the task, 14 seriating preschoolers were tested in Study 3. A significant stimulus effect was found. Results support the Piagetian position that operative schemes, rather that figurative memory skills are of primary importance in remembering operatively-derived stimuli accurately. Educational implications for LD children were also discussed.

Figurative and Operative Bases of Memory: Evidence from Normal and Learning Disabled Children

Piaget and Inhelder (1973) have hypothesized that memory is intimately linked to intellectual structure, and thus, that the recall of a picture or event is determined in large part by the operative level of the person recalling it. To test this hypothesis, Piaget and Inhelder asked children across a wide age range to recognize, reconstruct, and/or reproduce a variety of operatively-derived stimuli. As predicted, children's mnemonic responses were found to be comparable to responses typically given by children of the same ages on related anticipatory tasks. In the best-known illustration of this phenomenon, 3- to 8-year-old children were shown a seriated array of different-length sticks, and were then asked to reproduce this array one week later. Most of the youngest children (3- to 4-year-olds) reproduced the sticks without any regard for size order; somewhat older children (5-year-olds) ordered the sticks partially, for example, by alternating large and small sticks or by drawing two separate sets of three seriated sticks; while the oldest children (6- to 8-year-olds) reproduced the sticks in perfect size order. Similar cross-sectional differences have been reported by subsequent investigators (see Liben, 1977).

Although these cross-sectional data are consistent with the Piagetian position that memory varies as a function of the subject's operative level, these data are also consistent with the hypothesis that memory varies as a function of the subject's rote memory skills. Within the context of Piagetian theory, the notion of rote memory is most closely represented by the concept of "figurative" memory. Through figurative actions, the individual constructs knowledge about the static, configural aspects of the stimulus, and hence

figurative memory need not evoke operative (or transformational) schemes for retention of these aspects of stimulus. (More extensive discussions of the distinction and relation between figurative and operative processes may be found in Furth, 1969 and Piaget, 1970.)

Just as operative schemes become increasingly advanced with age, rote memory skills also improve with development (e.g., see Brown, 1975; Kail & Hagen, 1977). It is, therefore, possible that the superior memory of older children that has been observed in past Piagetian memory research may be attributable to better rote memory skills rather than to more advanced operative levels. The studies reported here were designed to investigate whether accurate memory for operatively-derived stimuli is more reasonably attributed to good figurative memory skills or to advanced operative schemes.

Study 1

In normal populations of children it is difficult to separate the effects of advanced operative level and good figurative skills, since both covary with age. Such a separation is, however, possible in learning disabled children who have demonstrably poor figurative memories. If it were found that concrete operational learning disabled children (with deficits in short-term visual memory) perform well on a standard Piagetian memory task, it would provide evidence that memory for operatively-derived stimuli need not rely upon good figurative memory skills.

To investigate this issue, concrete operational children--half with deficits in visual memory and half with normal memory skills--were given two types of memory stimuli. In one type of memory stimulus, the elements of the display were presented in an unorganized manner so that operative schemes would be of relatively little use for memory. In the second type of stimulus, elements were organized so that operative (seriation) schemes would be highly

relevent. A significant interaction between subject group (learning disabled versus normals) and type of stimulus (unorganized versus organized) was predicted, such that the learning disabled children were expected to perform significantly worse than normal children in reconstructing the unorganized stimulus (in light of their deficient figurative memories), but were expected to perform comparably to the normal children in reconstructing the organized stimulus (in light of their equivalent operative schemes).

Method

Subjects. The final group of subjects consisted of 60 children, divided equally between learning disabled and normal groups. Children in the learning disabled group were selected first, as described below. Normal children were then selected to match the learning disabled children on the basis of grade, age, sex, and IQ.

In the first stage of the selection of subjects, files from a private learning disabilities clinic and from the remedial reading classes of a suburban elementary school were examined to identify children who were average to above-average in intelligence; were performing below grade level in reading; had poor performance on memory tests; and had no severe perceptual, emotional, or sensory problems. Children meeting these criteria were then given additional tests, specifically, a) the Peabody Picture Vocabulary Test (PPVT), b) conservation of substance, length, and number tests from the Goldschmid-Bentler, and c) the visual sequential memory subtest of the Illinois Test of Psycholinguistic Abilities (ITPA). To be included in the final learning disabled group, children were required to have demonstrated at least normal intelligence (score of $\geq$ 90 on the PPVT), a visual sequential memory deficit (scaled score of $\leq$ 30 on the ITPA), and have concrete operational thinking (success on all conservation tasks of the Goldschmid-Bentler). Although an attempt was made to limit the

age range of subjects by identifying enough learning-disabled children from grades 1 and 2, it was necessary to include older children as well (grades 3 and 4) in order to obtain the desired sample size of 30. The final learning-disabled group included 3 boys from grade 1, 7 boys and 1 girl from grade 2, 5 boys and 2 girls from grade 3, and 9 boys and 3 girls from grade 4. The preponderance of boys was dictated by subject availability, and reflects the fact that more boys than girls are diagnosed as learning disabled (Bannatyne, 1971).

Once the children for the learning disabled group had been obtained, normal children from the same suburban elementary school were given the tests named above (i.e., the PPVT, ITPA, and Goldschmid-Bentler). The children comprising the normal group were selected to match the learning disabled children by sex, grade, and age. The mean age of the final group of learning disabled children was 9 years, 4 months; and of the final group of normal children was 9 years. Mean intelligence scores were 111 and 116, respectively. Since a prerequisite for selection was that the child be concrete operational, all children in both groups had passed all items of the Goldschmid-Bentler. In contrast, since a memory deficit was a selection criterion for the learning disabled group only, the learning disabled children had significantly lower scores than the normal children on the visual sequential memory subtest of the ITPA ($\bar{X}$'s = 28 and 42, respectively), $F(1, 58) = 124.71$, $p < .001$.

Procedure and materials. All children were tested individually by the first author in two sessions. The tasks described above for the selection of subjects were administered in the first session using procedures described in the appropriate test manuals.

The memory tasks were given in the second session. Each subject was given a practice test, followed by the experimental memory tasks, in counter-

balanced order. For the practice task, three blocks (red cylindrical, blue rectangular, and red rectangular) were placed from left to right in a row. As described earlier, two stimuli were used for the experimental memory tasks. The unorganized stimulus consisted of 7 wooden dowels of different colors (each 15 cm in length x .7 cm in diameter), glued on tag board (in order, from left to right: yellow, light blue, black, orange, dark blue, green, red). The organized stimulus consisted of 7 dowels of different lengths (again .7 cm in diameter) glued on tag board in size order from smallest to largest (11 cm to 17 cm, with 1 cm increments). Thus, the unorganized and organized stimuli contained the identical number of sticks, presented in the same way, but with different bases for ordering (color versus size).

For each memory task, children were told to look at the display carefully so that they could make an identical picture after it had been removed. The model was presented for 15 seconds. Following the removal of the stimulus, a duplicate set of materials was given to the subject who was asked to reconstruct the picture from memory. There was no time limit for completion of the reconstructions.

Scoring. Three scores were used to measure the accuracy of reconstructions. First, an absolute score reflected the number of sticks placed in exactly the same position as those in the model, with one point assigned for each stick in the appropriate position (maximum score = 7). Because a single error (such as putting the left-most stick on the extreme right but having all other sticks in the correct relative order) could result in an unduly low score (in the example given, a score of 0), an order score was also used. For this score, the reconstructions were broken into six pairs of sticks, and one point was assigned whenever the second stick of the pair was "in order" with respect to the first, that is, when it appeared later in the sequence than the first

stick (maximum score = 6). "In order" for the unorganized stick stimulus referred to color, while for the organized stick stimulus, it referred to length. Finally, a combined score was used to assess the extent to which the reconstruction preserved both order and exact position information of the model. For this score one point was assigned for each pair of sticks in which each stick was in the appropriate position and the second stick was in order with respect to the first (i.e., later in the color/length sequence). Since both conditions had to be met to score a point, this was the most stringent scoring system used (maximum score = 6).

Results

To analyze performance on the memory tasks, a 2 (Group: learning disabled versus normal) X 2 (Stimulus: unorganized versus organized) analysis of variance, with repeated measures on the second factor, was performed for each of the measures described above. With the absolute score as the dependent measure, the analysis of variance revealed a significant Group X Stimulus interaction, F (1, 58) = 19.95, $p < .001$, with the two subject groups performing equivalently on the organized stimulus, but the normal group performing significantly better than the learning disabled group on the unorganized stimulus. As implied by the significant interaction, there were also significant main effects of group, F (1, 58) = 19.95, $p < .001$, and stimulus, F (1, 58) = 114.93, $p < .001$. The comparable analyses for order scores and combined scores yielded an identical interaction and main effects, and thus are not reported in detail here. Group means for each of the measures are shown in Table 1.

Insert Table 1 about here

Discussion

As predicted, a significant Group X Stimulus interaction was found, such that memory in the learning disabled children was worse than memory in the normal children on the unorganized stimulus but not on the organized stimulus. This finding held regardless which score was used as the dependent measure (absolute, order, or combined). These data suggest that the difficulty that learning disabled children have in reproducing visually-presented stimuli can be overcome when their operative schemes can be used to organize their memories.

The results from the present study are, therefore, consistent with the Piagetian position that memory for operatively-derived stimuli is enhanced by advanced operative schemes and is not necessarily dependent upon good figurative memory.

It must be recognized, however, that an alternative explanation for the observed interaction also exists, namely that the organized stimulus is simply figuratively easier than the unorganized stimulus. From a Piagetian perspective, however, if the organized stimulus appears to be figuratively less demanding than the unorganized stimulus, it is only because operative schemes may be used to organize or "chunk" the elements of the stimulus. Without seriation schemes, this organization should not be possible, and thus the two stimuli should not differ in task difficulty (since both sets contain otherwise comparable figurative elements). To evaluate this interpretation, a second study was conducted as described below.

Study 2

If, as argued above, the crucial difference between the unorganized and organized stimuli is that operative schemes may be applied to the latter but not to the former, but that otherwise the figurative demands of the two tasks are equivalent, it should be true that children who lack the relevant operative

schemes would find the two stimuli equally difficult. This assertion was tested in Study 2 by giving both memory stimuli to children who lack seriation schemes. If, as hypothesized, the tasks are equivalent figuratively, there should be no significant differences between performance on the arbitrary and organized stimuli in these children.

Method

Subjects were 20 preschool children, approximately equally divided between boys and girls, whose mean age was 4 years, 6 months. As before, children were tested individually by the first author. The procedures for the memory task were like those described in Study 1, except that two additional practice tasks were given to ensure that preschoolers understood the directions. In these additional practice tasks, children were asked to reconstruct each of two rows of items from memory, one row containing a circle and two diagonal lines, and the second containing a square, star, and a circle. After children completed the memory tasks, they were asked to seriate seven orange circles, ranging in size from 6 cm to 3 cm in diameter, with .5 cm increments. Only children who failed to seriate the circles correctly ("nonseriaters") were included as subjects. The scoring procedures for the memory tasks were identical to those used in Study 1.

Results

The mean reconstruction scores for each memory stimulus are given in Table 2. With absolute scores used as the dependent variable, no significant

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Insert Table 2 about here

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difference was found between performance on the unorganized and organized stimuli, $t(19) = 1.31$, n.s. Parallel analyses with the other two measures yielded comparable findings.

Discussion

As hypothesized, there was no significant difference in performance on the unorganized and organized stimuli in children who do not have the relevant operative schemes. This finding argues against the possibility suggested earlier that the reason that learning disabled children performed as well as normals on the organized stimulus in Study 1 was simply because the organized stimulus was figuratively simple, and hence could be remembered with even the deficient memory capabilities of learning-disabled children.

It is, of course, also possible that the failure to find a significant task effect in Study 2 might reflect young children's general inability to remember such stimuli at all (or a general inability to understand the directions), rather than reflecting underdeveloped operative schemes. Additional data bearing upon this interpretation were therefore collected in Study 3.

Study 3

To determine whether very young children are, indeed, capable of understanding the task demands and perform in accordance with predictions based on Piagetian theory, the memory tasks used in the earlier two studies were given to children of approximately the same age as those in Study 2, but who were able to seriate. Since these children possessed the relevant operative schemes, it was hypothesized that they would show significantly better memory for the organized stimulus than for the unorganized stimulus.

Method

Procedures used were identical to those of Study 2, except that children included for this study were successful on the seriation task ("seriaters"). Included in this group were 14 children, approximately half boys and half girls, with a mean age of 5 years.

Results

The mean reconstruction scores for each measure are also shown in Table 2. With absolute scores as the dependent measure, performance on the organized stimulus was significantly better than performance on the unorganized stimulus, $t(13) = 5.82$, $p < .001$. Comparable findings were obtained with the other two measures as well.

Discussion

As predicted, very young children with the relevant operative schemes did show significantly better memory for the organized stimulus than for the unorganized stimulus. This finding suggests that the failure to find a significant effect of stimulus in Study 2 cannot be explained simply as an inability of children at this age to understand the task. The contrast in findings between Studies 2 and 3 is particularly compelling because the seriaters and nonseriaters obtained approximately equivalent scores on the unorganized stimulus (see Table 2), suggesting that their figurative memories are comparable. Statistical support for this statement is derived from an additional analysis in which data from Studies 2 and 3 were combined, specifically, in a 2 (Group: seriaters versus nonseriaters) X 2 (Stimulus: unorganized versus organized) analysis of variance. A significant Group X Stimulus interaction was found for each dependent measure (e.g., with absolute scores, $F(1,26) = 17.67$, $p < .001$) such that the seriaters and nonseriaters performed equivalently on the unorganized stimulus, but the seriaters performed significantly better than the nonseriaters on the organized stimulus.

General Conclusions

The combination of findings from the three studies described above provides strong support for the Piagetian position that variations in operative schemes, rather than in figurative memory skills, are of primary importance in

remembering operatively-derived stimuli. The results from Study 1 showed that even children with poor figurative memory skills (learning-disabled children) are able to perform as well as their normal peers on a memory task to which they could apply their operative schemes, although as expected from their significantly worse performance on a standardized test of visual short-term memory (ITPA), they did perform worse than normals when asked to remember a stimulus for which these operative schemes were not relevant. Although it was recognized that the Group X Stimulus interaction observed in Study 1 might simply indicate a significant difference in the figurative difficulty of the two stimuli, Studies 2 and 3 indicated that the two stimuli were not differentially difficult, unless the viewer possesses the relevant seriation schemes.

Thus, the contrasts between grade school children with normal versus deficient figurative memory skills, and between preschool children with versus without seriation schemes, are fully consistent with the predictions of Piagetian theory.

In addition to providing support for the operative interpretation of the cross-sectional age differences found in past Piagetian memory research, the present findings also suggest that it may be possible to teach learning disabled children to improve their memory skills by instructing them to impose organization on the material to be learned. Such organization could reduce the rote memory demands of the learning task, and thus partially compensate for the child's memory deficits. Imposed organization may be possible even in highly arbitrary learning tasks. For example, a re-examination of the unorganized stimulus used in the present studies reveals at least two meaningful color combinations: black and orange, symbolizing Halloween, and green and red symbolizing a traffic light. Although these examples are admittedly post hoc and strained, it should be remembered that the stimulus was intentionally

designed to be devoid of meaning, and that in contrast, most memory tasks children encounter in school (e.g., see Brown, 1975) are likely to be more susceptible to an organizing strategy. Thus, the findings of the present studies provide support for the Piagetian interpretation of past empirical work and, in addition, suggest avenues that may be useful for remediating memory deficits in learning-disabled children.

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Footnote

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Table 1

Learning Disabled (LD) and Normal Children's Reconstruction Scores on Unorganized and Organized Stimuli

Measure	Max. Score	Unorganized		Organized	
		LD	Normal	LD	Normal
Absolute	7.0	3.6	5.6	7.0	7.0
Order	6.0	4.3	5.2	6.0	6.0
Combined	6.0	1.8	4.1	6.0	6.0

Table 2

Preschool Children's Reconstruction Scores on Unorganized and Organized Stimuli

Measure	Max. Score	Nonseriaters (Study 2)		Seriaters (Study 3)	
		Unorganized	Organized	Unorganized	Organized
Absolute	7.0	.8	1.3	2.1	5.8
Order	6.0	3.0	3.1	3.5	5.6
Combined	6.0	.2	.4	.8	4.8